Chapter 16
Temporary Polypseudophakia (Piggyback IOLs)

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When a cataract is removed from a child's eye, the critical offset to axial eye growth is also removed. The process of emmetropization requires a crystalline lens to change its focusing power to match axial eye growth in an attempt to keep the image focused on the retina. We currently do not have any artificial intraocular lens (IOL) implants that automatically change as the eye grows. If the surgeon aims for emmetropia at the time of IOL insertion in a growing eye, myopia will develop over time. When surgery for cataracts is done early in life, this change in refractive error can create high degrees of myopia in a few years or even months. Surgery to exchange an IOL that is firmly "shrink-wrapped" into the capsular bag can be challenging. For these reasons, pediatric eye surgeons often aim for hyperopia immediately after cataract and IOL surgery when operating on young children and rely on glasses to correct the residual refractive error during eye growth. However, poor compliance with glasses can worsen amblyopia despite the presence of the IOL. A toddler may require 5 or 6 diopters (D) of intentional residual hyperopia after surgery if the goal is to achieve emmetropia at maturity and throughout adulthood. This approach reduces the chances that an IOL exchange will be needed when growth is complete. However, the downside is that if the glasses are not worn full time, the uncorrected residual hyperopia is amblyogenic, especially for children whose visual world is mostly at near.

With these concerns in mind, one of the authors (MEW) introduced the concept of temporary multiple IOLs (or polypseudophakia or piggyback IOL) [1]. Primary implantation of multiple IOLs has been described to provide adequate IOL power to adult patients when sufficient power of a single IOL was not available [2]. In contrast to adults where primary piggyback IOL is intended to stay permanently, in children with temporary polypseudophakia, the posterior IOL is implanted in the capsular bag (permanent) and the anterior IOL is placed in the ciliary sulcus

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(temporary), a location from which it may be easily removed at a later point. This concept reduces the amount of hyperopia during infancy and myopia during adulthood by removing the anterior IOL when the eye becomes sufficiently myopic. It is well known that hyperopia is more amblyogenic than myopia. With this technique, during the critical period of visual development, patients are able to minimize the need to wear thick spectacles or contact lenses. We are following 40 children (51 eyes) implanted with primary temporary polypseudophakia and 44 of those eyes now have more than 5 years of follow-up. The median follow-up of those 44 eyes is 12.24 years. Planned piggyback IOL removal has occurred at a median of 3.24 years after implantation. Only four eyes underwent unplanned, early piggyback IOL removal, one each for IOL tilt, pupillary block, pupillary capture, and a pupillary membrane. Each of those complications occurred when the piggyback technique was used on infants younger than 7 months of age.

Case Report

A 22-month-old female child presented with a diagnosis of bilateral anterior polar cataracts since birth. The cataract in the left eye had gradually progressed over the preceding few months and was visually significant. A sensory exotropia had developed and the child strongly objected to having the right eye covered. The cataract in the left eye was a pyramidal anterior polar opacity with extension into the underlying cortex and nucleus, while a very small anterior polar cataract in the fellow right eye was visually nonsignificant. Examination under anesthesia was scheduled along with surgery on the left eye. The globe axial length (AL) of the left eye was 0.61 mm longer than the right eye, further suggesting the presence of deprivation amblyopia (Table 16.1). After thoroughly discussing options with the parents, piggyback IOLs were selected as it was felt to be the best way to visually rehabilitate the eye. The child was nearing her second birthday and the parents acknowledged that full-time spectacles would be a burden and they were fearful that they would not be able to comply. Biometry predicted an IOL power for emmetropia of 27.76 D (calculated

Table 16.1 Preoperative parameters

	RE	LE
IOP (mmHg)	10	9
Keratometry (D)	42.25/45.25	43.50/49.50
Axial length (mm)	20.23	20.84
Anterior chamber depth (mm)	3.33	3.26
Lens thickness (mm)	3.67	4.21
Corneal diameter (mm)	11.5	11
Corneal thickness (μm)	573 ± 2.3	547 ± 4.3
Refraction (D)	+3 sph +0.5 cyl @100	Not possible

D diopter, *mm* millimeter, *μm* micrometer, *sph* sphere, *cyl* cylinder, @ axis

Table 16.2 Left eye refraction

Age (yrs)	Follow-up duration	Sph	Cyl	Axis	SE
1.94	1 week	−1.5	+2.5	90	−0.25
2.05	6 weeks	+0.75	+1.00	75	+1.25
3.55	1.6 yrs	−0.50	+0.50	90	−0.25
3.76	1.8 yrs	−0.75	+0.50	90	−0.50
5.08	3.2 yrs	−1.75	+0.75	85	−1.38
6.54	4.6 yrs	−2.50	+0.75	85	−2.13
7.46	5.5 yrs	−5.25	+1.00	90	−4.75
8.21	6.29 yrs (PB IOL explantation)	−6.00	+2.00	90	−5.00
8.36	6.44 yrs (2 months post explantation)	−1.25	+1.25	75	−0.63

PB IOL piggyback IOL, *Yrs* years, *Sph* sphere, *Cyl* cylinder, *SE* spherical equivalent

using Holladay 1 formula). With a +21 D IOL chosen for implantation into the capsular bag, the predicted residual refraction in the spectacle plane was +4.01 D. It was decided to implant a +21 D AcrySof® SN60WF into the capsular bag and a +6 D AcrySof® MA60 into the ciliary sulcus. Biometry had predicted that if a total of +27 D of IOL power was implanted, the predicted refraction immediately post-op would be +0.52 D. Since eye growth is very active at age 2, it was predicted that she would become emmetropic and even mildly myopic within months of surgery. Surgery was uneventful. Both of the IOLs were well centered and we did not prescribe glasses after surgery. At 1 week after surgery, the refraction was −0.25 SE (Table 16.2).

Globe AL measurements were done at 3.8 years of age (1.8 years after cataract surgery). The globe AL was 21.20 and 21.36 mm for right and left eye, respectively. Biometry predicted a refraction of +4.80 D with only a +21.0 D IOL (if the 6 D is explanted). Corneal thickness was 559 ± 1.5 and 582 ± 2.1 μm in the right and left eye, respectively. Refraction at this visit was −0.5 D SE (Table 16.2). At age 5 years, her refraction was −1.50 D SE and she was wearing glasses sparingly. By 8.2 years of age (6.3 years after cataract surgery), her refraction was −5 D SE (wearing glasses part time) and we decided to proceed with piggyback IOL removal. Axial length was 22.34 and 22.75 mm, respectively. Sulcus IOL explantation was uneventful (Fig. 16.1a, b). At the most recent visit, the child was 8.4 years old. Her best-corrected visual acuity was 20/20 in the right eye and 20/25 in the left eye. Her refraction in the pseudophakic left eye was −1.25+1.25X75. Unlike when she was age 2, at age 8 she is comfortable putting on glasses when needed. The IOP was under control (16 and 20 mmHg in the right and left eye, respectively). The very small anterior polar cataract in the fellow right eye cataract was still visually nonsignificant.

Comment For piggyback IOL power calculation, it is recommended that the surgeon decide on the lens power for the anterior, temporary IOL first. The power of this IOL is chosen based on how much refractive change is anticipated during growth and development. A worldwide opinion paper utilizing the Delphi method reported a consensus among surgeons for immediate postoperative target refractions (based on expected refractive change during growth) as follows: age at surgery

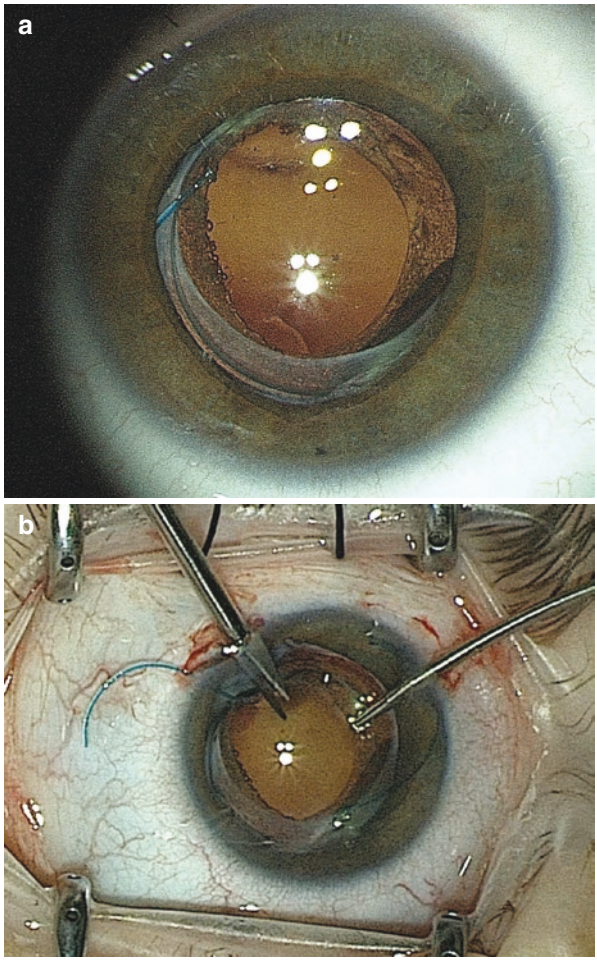

Fig. 16.1 (**a**, **b**) Postoperative view at the time of planned explantation (2-A) and piggyback IOL explantation in progress (2-B)

<6 months, +6–10 D; 6–12 months, +4–6 D; and 1–3 years, +4 D [3]. One method for estimating the needed piggyback IOL power is to multiply the targeted hyperopic postoperative refraction by 1.5. This method was developed for adults to calculate the anterior bag-fixated IOL power. Since the temporary IOL is placed in the ciliary sulcus, a minor adjustment in power is needed if the anterior lens is >+8.5 D. The adjustment of power from capsular bag to sulcus position is reducing by 0.5 D lenses from +8.5 D to +15 D and reducing by 1 D for lens from +15.50 D to +25 D [4]. In the case example, if a single IOL was selected, the immediate postoperative refractive target would have been +4. Based on this, a +6 piggyback IOL was selected for the sulcus-placed lens. Another suggested calculation is to place 20% of the total power for emmetropia in the piggyback IOL [5]. In the above case, 20% of the power needed for emmetropia would have been 5.6 D, which also concurs closely with our choice of +6 D of IOL power.

The second step is to calculate the power of the IOL that will be placed in the capsular bag. For the patient described, the total power needed for emmetropia was +27.76 D. and a +21 D was selected for the capsular bag-fixated IOL to be combined with the +6 selected above. We used the Holladay 1 formula for the calculations. However, the Holladay 2 formula can also be used for selecting a power for the posterior lens, once the sulcus IOL power is determined. In this case, with a +6 D anterior lens, the Holladay 2 formula predicted a need for a +23.5 D IOL for immediate postoperative emmetropia.

The operative technique of piggyback IOL implantation is similar to that used for single IOL insertion, except that an additional IOL is implanted in the ciliary sulcus immediately after the initial IOL is placed in the capsular bag. It is very important to remove the ophthalmic viscosurgical device (OVD) from the capsular bag after the first IOL is placed and then fill the ciliary sulcus with additional OVD. A common mistake is to inset the piggyback IOL without first emptying the bag of OVD. Doing that will make the implantation of the second IOL more traumatic for the eye, resulting in more iris trauma and more postoperative inflammation. A single-piece acrylic IOL is used most often for placement within the capsular bag. For sulcus fixation, we recommend a three-piece acrylic IOL.

Interlenticular opacification (ILO), a complication of piggyback IOLs in adults, is avoided in pediatric patients because one of the IOLs is placed in the ciliary sulcus [6]. Interlenticular opacification seems to be related to two IOLs being both implanted in the capsular bag through a small capsulorhexis, with the rhexis margin overlapping the optic edge of the anterior IOL for 360°. Analyses of cases of ILO concluded that the opacification within the interlenticular space is derived from retained/regenerative cortex and pearls from the capsular bag equator growing between the 2 optics within the confined space of the capsular bag. In the case example, an Alcon AcrySof SN60WF® was chosen for the permanent capsule-fixated IOL. Alternatively, the Alcon MA50BM® IOL, which has the majority of its power on the posterior surface, is recommended by some adult surgery websites, such as Warren Hill's doctor-hill.com site [4], when piggyback IOLs are planned in adults. The design of this lens allows for the lowest possible profile at the level of anterior lens capsule.

It has been our hope that visual acuity outcomes would be better after piggyback IOL implantation compared to when uncorrected hyperopia occurs after single IOL placement. Theoretically, slowing increasing myopia after IOL surgery in young children is less amblyogenic than initially high hyperopia that slowly decreases. This seems logical given that hyperopic error is highest in early childhood when amblyopia risk is the highest. This superior benefit would only be realized for those children who comply poorly with wearing spectacles after surgery. In the sample case, the visual acuity outcome has been excellent, despite poor glasses compliance and many cancelled appointments over time. We have no data that indicate this outcome would have been worse had we not used piggyback IOLs. In fact, we have a marked negative selection bias, meaning that we often select this technique in settings of delayed presentation or when poor compliance with glasses or patching is anticipated. That makes any comparison of visual outcomes in piggyback IOLs to

single IOLs meaningless in our cohort. Instead, we have concentrated on a comparative analysis of safety. It would take a randomized trial to adequately compare outcomes. Since the technique is surgically aggressive, we do not often choose piggyback IOLs for children predicted to be excellent at wearing glasses and patching.

The best time to explant the anterior IOL is when biometry predicts a refractive error near plano when calculated using only the posterior IOL power. Boisvert, Beverly, and McClatchey have published their thoughts on choosing piggyback IOL powers [5]. They suggest that the anterior IOL can be removed when the child's myopia equals half the anterior IOL power.

IOLs placed in the ciliary sulcus do not scar in place and they can be easily rotated, exchanged, and removed even several years after implantation. This has been a consistent finding for us over many years. We have not had any difficulty performing any of the planned IOL removals.

The final question remains whether temporary polypseudophakia is recommended for children. Hwang and colleagues reported that compared with the primary single IOL implantation, their temporary piggyback IOL implantation group had higher complications [7]. In the authors' cohort, we have not noted more inflammation, glaucoma, or visual axis opacification compared to age-matched single IOL surgery. Each of our four unplanned early IOL removals came after the technique was used in the first 7 months of life. Now, in our practice, these children are most often left aphakic based on the recommendations of the Infant Aphakia Treatment Study [8]. For surgery on children ages 7 months–5 years, the piggyback technique is employed when compliance with postoperative spectacles is expected to be poor. We believe that this technique can be beneficial in select children. It is not intended or recommended for every infant and toddler needing IOL surgery. For those families who can comply with glasses or contact lenses, the effects of residual refractive error can be managed without needing to place multiple IOLs in the eye. The surgery can be technically challenging and requires a reoperation some years later to remove the sulcus-placed IOL. The placement of piggyback IOLs is a surgical approach that should be used when needed but avoided in favor of a less traumatic surgery whenever possible. To summarize, infants and toddlers who are anticipated to have difficulty complying with contact lens wear and amblyopia therapy can be considered candidates for piggyback IOL implantation.

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